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WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH–I–00–08–00024–00 ORDER NO. 04

AS SAMRA BIOSOLIDS MONOFILL OPERATIONS AND MAINTENANCE (O&M) MANUAL

June 2015

IMPLEMENTED BY AECOM

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AS SAMRA BIOSOLIDS MONOFILL OPERATIONS AND MAINTENANCE (O&M) MANUAL JUNE 2015

Submitted to:
USAID Jordan

Prepared by:
AECOM

CONTENTS

Appendices:

LIST OF ACRONYMS

BOD	Biochemical Oxygen Demand
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
CPR	Cardio Pulmonary Resuscitation
EGTL	Explosive Gas Threshold Limit
ET	Evapotranspiration
GCL	Geosynthetic Clay Liner
HDPE	High Density Polyethylene
ISWA	International Solid Waste Association
Km	Kilometers
LEL	Lower Explosive Limit
LFG	Landfill Gas
LGP	Low Ground Pressure
mm	Millimeter
MSW	Municipal Solid Waste
MWI	Ministry of Water and Irrigation
O&M	Operation and Maintenance
PPE	Personal Protection Equipment
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
TBD	To Be Determined
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WWTP	Waste Water Treatment Plant

1 Purpose and Scope

The objective of this manual is to provide guidance on how to successfully operate and maintain the As Samra Biosolids Monofill. As such, this manual can be used in outlining the necessary basic tasks, techniques and processes expected to be performed and undertaken on-site for effective day-to-day management of the facility.

The scope of this document covers technical and safety matters such as biosolids placement; periodic soil cover; landfill gas control and fire prevention; nuisances (i.e. dust, odor, vectors); leachate management and surface water control; site management and maintenance; and monitoring requirements in the context of the site. Furthermore, best practices pertaining to liaison with the general public and the informal sector are identified and presented. This manual can therefore serve as an effective tool to ensure the mitigation of environmental and social impacts caused by the landfill.

This Manual is divided into sections as follows, with appendices providing supplementary information:

- Section 1.0 - Purpose and Scope
- Section 2.0 - General Information
- Section 3.0 - Facility Design
- Section 4.0 – Personnel and Training
- Section 5.0 – Operation and Maintenance
- Section 6.0 – Inspection Plan
- Section 7.0 – Site Closure and Long Term Care
- Section 8.0 - Emergency Response Plan

2 General Information

2.1 Location and Service Information

The As Samra Wastewater Treatment Facility (WWTP) services a population of approximately 2.265 million people mainly in Amman and Zarqa, and is located on land owned by the Ministry of Water and Irrigation (MWI) in Al Khirbeh As-Samra area within Al Hashimiyya in Zarqa governorate, 13 km north of Zarqa and 36 km to downtown Amman (see Figure 2.1). The monofill facility is accessed from an approximate 5.2 km long minor road off Route 25 major highway in town of Alhashemiah Aljdedah.

Figure 2.1: Regional Site Map

As Figure 2.2 shows, the monofill will be located to the northwest of the WWTP and existing drying lagoons on mostly barren land in an area occupied by a serpentine wadi

and an abandoned chlorine facility (building refurbished for use as the monofill administrative building).

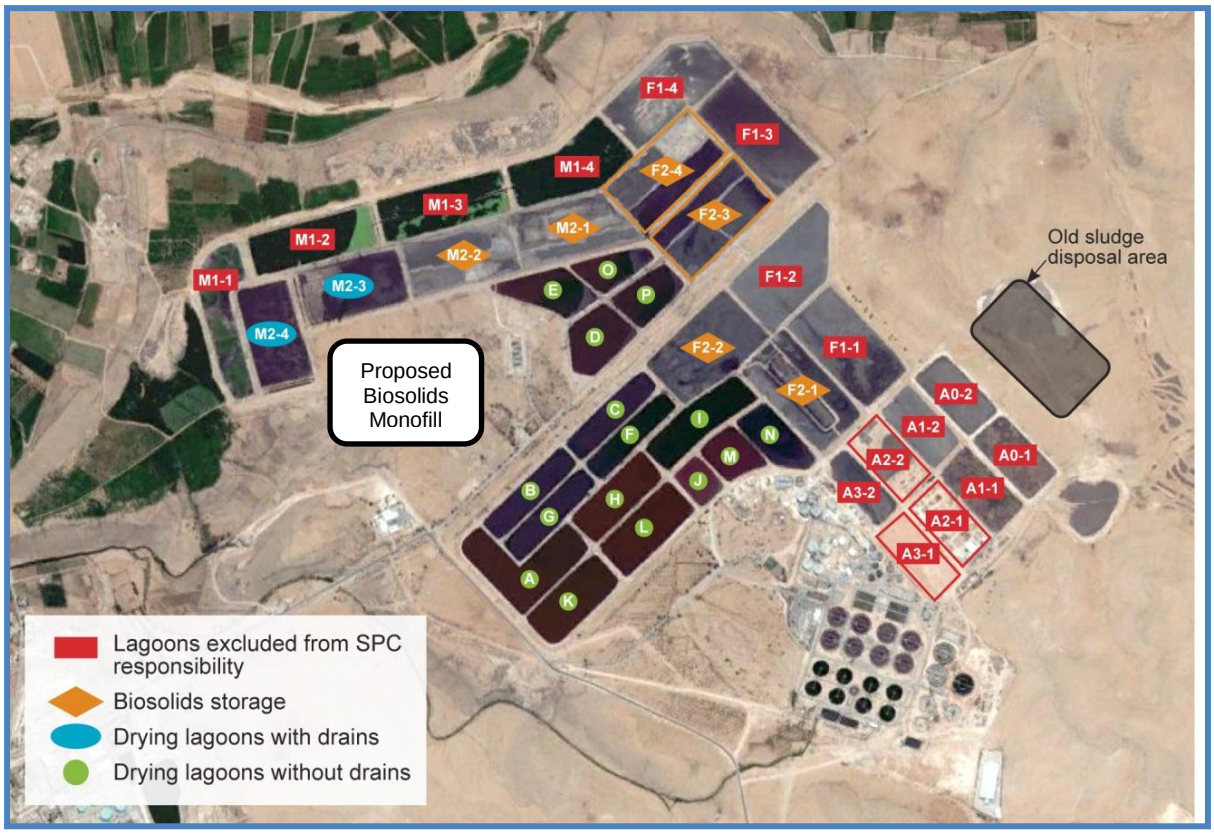

Figure 12.2: WWTP Lagoon Use Plan and Biosolids Monofill Location

Site Center Location: Longitude: 36° 9' 50.38" / Latitude: 32° 9' 15.28"

Operator: To be determined through contract bid process

Monofill Size: Occupies approximately 38 hectares within existing As Samra Waste Water Treatment Plant (WWTP) land area.

Proposed Disposal Area: 195,616 square meters (19.56 hectares)

The Monofill will receive dried biosolids material from the As Samra Wastewater Treatment Facility sludge management area. WWTP or Contract haulers will transport biosolids waste from drying areas within the WWTP property and transport to the landfill via over-the-road bi or tri-axle hauling trucks.

2.2 Applicable Regulatory and Legislative Framework

Jordan does not presently have comprehensive regulations specifically relevant to biosolids monofills. Therefore, regulations in the United States have primarily been used as a basis for design on this project. In the United States, Subpart C of Title 40 of the Code of Federal Regulations (40 CFR), Part 503 provides relevant regulations developed by the Environmental Protection Agency (USEPA) for lining biosolids monofills. Should the biosolids produce leachate with unacceptable levels of contaminants (*arsenic, chromium and nickel*), then a base liner containment system with leachate collection and treatment is required per Part 503.

Test results for sludge quality relative to arsenic, chromium and nickel at As Samra are presented in the Terms of Reference – As Samra Sludge Management (Treatment Re-use and Disposal) Feasibility Study (AECOM, November 2012) and are summarized as:

- Arsenic < 7.5 mg/kg of dry weight
- Chromium 67 (37-176) mg/kg of dry weight
- Nickel 37 (24-60) mg/kg of dry weight

These reported values are all currently less than the maximum allowed pollutant concentration limits for all distances per Table 1 and Table 2 of Section 503.23. Part 503 also allows for construction of a single liner system in-lieu of further substantiating if there are unacceptable levels of arsenic, chromium and nickel at the boundary of the facility. Therefore a single geomembrane liner with a leachate collection system will be installed at the biosolids facility to ensure into the future that potential unacceptable levels of contaminants from biosolids disposal are not encountered at the facility boundary in the future.

Part 503 also necessitates that measures be taken for closure and post-closure care, leachate collection (if the unit is lined), methane monitoring, and public access restrictions. In addition to these measures, managerial requirements similar to those for municipal solid waste (MSW) monofills must also be met. These include requirements for runoff collection, leachate collection and disposal (if the unit is lined), vector control, methane monitoring, groundwater monitoring or certification, public access restrictions, and restrictions for the growing of crops and grazing of animals.

2.3 Site Description

The monofill and its support facilities will ultimately encompass approximately 38 hectares of area on barren land that has a serpentine wadi valley initiating from the approximate southeastern edge and sloping generally towards the northeast corner. The land generally slopes northwards from the southern edge of the proposed site towards the wadi and southwards from the northern edge of the proposed site towards the wadi. The steepest slopes (up to approximately 30%) occur in the valley feature incised by the wadi. The site is bound on the north and east by the existing WWTP drying beds and on the south by an existing access road.

The former administration and chlorine handling building and electrical equipment located along the roadway on the south side of the site will be re-furbished and used as the administrative office for the monofill. The existing chlorine contact basin and its service pipes and structures near the eastern edge of the proposed site will be removed.

The As Samra area has a dry desert climate, characterized by very hot summers and mild winters. Data from the Al Zarqa Al Jadeida weather station indicate an average maximum temperature of 25.8°C, and average minimum temperature of 13.9°C. Average monthly rainfall for 2009-2013 was 10.5 mm/month with an average annual rainfall of 125.6 mm/yr.

2.4 Waste Stream Information

The existing As Samra WWTP produces biosolids with a solids concentration on the order of 2%. After application of mechanical pressure within a belt filter press to achieve a solids content of approximately 18%, “solar drying” of the caked solids can be implemented to increase the solids content to at least 50% using evaporation lagoons. Drying from 18% to 50% solids takes approximately 2 to 3 months at the As Samra facility. It is assumed that solar drying to a solids content of no less than 50% will occur at the treatment plant. When solids content is greater than or equal to 50%, the biosolids material will be loaded onto dump trucks and taken to the As Samra Biosolids Monofill for disposal (see Figure 2.3).

Figure 2.3: Typical Loading of Dried Biosolids at WWTP Drying Beds

2.5 Introduction to Landfilling/Monofilling

While the As Samra facility is designated for disposal of biosolids, its operation as a monofill means that it will share characteristics of the "sanitary landfill" classification. According to the International Solid Waste Association (ISWA), sanitary landfill sites typically contain the characteristics presented in Table 2.1 below (edited to focus on biosolids monofill sites in arid environment):

Table 2.1 Summary of Landfill (as applicable to Biosolids Monofill) Characteristics

CRITERION	FACILITY CHARACTERISTICS
Aesthetics, quality of life, public health and safety	– Minimize wind-blown dust – Well-designed and maintained roads free of mud, dust and debris – No erosion – No disease vectors and minimal birds on site – Minimal odors – Wastes confined to one working face, compacted immediately, covered daily – Restricted access
Groundwater protection	– Fully lined, cover designed to control percolation – Full on-site leachate collection and treatment systems – No groundwater extraction within 500 meters of waste – Groundwater monitoring at least twice a year (elevation, quality and flow direction)
Surface water protection	– All contact run-off is collected and treated as leachate on site – Other run-off to sedimentation pond prior to discharge – Waste area bordered by berms – Prevention of ponding on-site – Isolation from surface water bodies, wetlands and floodplains
Landfill gas	– Full lining limits risk of gas migration – Active gas extraction and collection for flaring or potential re-use – Monitoring systems installed to monitor gas in buildings and soil – Buildings at least 300 meters away from waste
Occupational health and safety	– Waste covered immediately, except at working face, which is covered daily – Incoming waste confined to one working area and compacted immediately – Careful checking and routine rejection of hazardous or unwanted waste – Worker safety and operational procedures training – Dust and vector controls
Social impacts	– Free of trespassers – Site is secured through restricted access
Economic considerations	– Aftercare provision for at least 30 years after closure – Potential revenue from landfill gas valorization (beneficial re-use) – Cost for leachate treatment
Legislation	– Specific legislation and regulations (see Section 2.2)
Planning	– Planning and permit requirements

3 Facility Design

3.1 General Design Concept

3.1.1 Site Constraints

The proposed As Samara Biosolids Monofill will be constructed within an area of predominantly barren land that has a serpentine wadi valley initiating from the approximate southeastern edge and sloping generally towards the northwest corner of the development area. A runoff diversion channel has been designed to collect stormwater from the existing southern, eastern edges of the development area that currently flow towards the wadi. The diversion will collect run on and direct it in a counterclockwise direction around the monofill footprint until it rejoins the existing wadi at the northwest corner.

The solids content for the biosolids (mass of solids divided by total mass) shall be ≥ 50%. Disposal of biosolids within the monofill will be limited to periods when precipitation and excessive wind are not forecasted. Stability of the landfill, prevention of odors, and prevention of re-activation of biological processes are predicated on “dry” conditions. An adequate supply of soil daily cover material will be available for covering the biosolids at the end of each work day and in advance of wet weather conditions.

3.1.2 Engineering Design Concepts

As indicated previously, 40CFR, Subpart C, Part 503 has been utilized for design of the As Samra Biosolids Monofill. Key components of the engineering design consist of an access road, a base liner system, leachate management system, landfill gas management system, surface water management system, and final closure cap. These design elements are described in brief below and are detailed within the drawings included in the Design Report.

3.2 Design Elements

3.2.1 Access Roads

The monofill will be accessed via the existing roadway south of the development area and a new paved access ramp/scale road east of the former administration and chlorine handling building, which will be used as the monofill administration building. This arrangement will utilize the existing roadway and allow immediate visibility of incoming/egressing monofill traffic to operations personnel stationed at the administration building at the facility entrance. The access road will be cleaned and maintained throughout the active life and into the post-closure period of the monofill.

A perimeter berm/access road will be constructed around the disposal areas. The access road portion of the perimeter berm will have a coarse aggregate surface that will be maintained throughout the active life of the monofill and into the post-closure period.

As operations continue and final monofill development grades are reached, an access road onto the final development surface will be constructed. The access road will provide stormwater management, access to the active disposal areas and access onto the final cap for construction and maintenance activities.

Access to the active disposal areas and on-site stockpiles will be provided by temporary haul roads. These roads will have either a coarse aggregate or a soil surface and will be constructed as needed. Temporary haul roads may also be constructed on the intermediate monofill development slopes to provide access to the active disposal areas.

3.2.2 Base Liner System

The monofill base liner system has been designed with the following components (top to bottom), as shown in Figure 3.1:

Figure 3.1: As Samra Biosolids Monofill Base Liner System

3.2.3 Leachate Management System

The proposed design for the leachate collection system will consist of perforated 150 mm diameter perforated SCH80 PVC lateral pipes (or an equivalent HDPE pipe as approved by the engineer) connected to a 225 mm diameter perforated SCH80 PVC trunk line (or an equivalent HDPE pipe as approved by the engineer) along the centerline of the cell. Perforations will be drilled along the lower half of the pipe at 60° angles from the perpendicular. The holes will be alternately staggered and will have a diameter of 15 mm unless alternate perforation size is required by the engineer for compatibility with the proposed coarse aggregate surrounding the pipes.

The piping will be incised into the 600-mm (minimum) thick sand/granular leachate collection/liner protection layer, which has been designed to maintain leachate head on the liner system of no more than 300 mm. The monofill base grade slopes will be no less than 1% along the leachate collection pipes and 2% (minimum) perpendicular to the pipes.

Leachate collected within the sump(s) will be pumped up to the crest of the perimeter of the cell to a subsurface 100-mm-diameter (minimum) HDPE force main leading to the leachate evaporation lagoon.

3.2.4 Landfill Gas Management System

Vertical gas extraction wells (perforated PVC piping connected to surface accessible well-heads) are proposed with connections to a flare station, monofill gas electric generator, and/ or other utilization facility(ies) via a network of HDPE collection laterals and header piping. Perforated collection pipe within sloped horizontal trenches may also be installed

at lower elevations in the waste mass in order to collect produced gas before final waste heights are reached and vertical wells are installed. As the gas cools in the collection system, moisture in the gas condenses. Gas collection piping will be sloped towards condensate traps (as applicable) to prevent pipes from becoming obstructed by accumulated condensate water. The system must also be designed to accommodate differential settlement by using flexible connections and pipe joints where practical/applicable and by using 2% (minimum) slopes for transmission piping on the monofill development surface.

3.2.5 Surface Water Management System

Stormwater conveyance structures (channels, culverts, and basins) for the As Samra Landfill have been sized using the peak flow calculated using the rational equation and the 20-year return interval. Additional capacity has been provided in drainage channels and the stormwater management basins for larger storms by incorporating a minimum 250 mm of freeboard above the 20-year storm flow depth.

3.2.6 Final Closure Cap

After final biosolids placement, a monolithic ET cover will be installed. The surface of the ET cover will then be covered with an aggregate layer for erosion control. The ET cover was chosen due to its proven suitability in arid and semi-arid areas, its limited long-term maintenance requirements, as well as its economic feasibility. As shown I Figure 3.2, the ET cover design for the As Samra monofill will consist of a minimum of 1350 mm (1.35 m) of ET native soil cover overlain by 150 mm (minimum) of aggregate for erosion control.

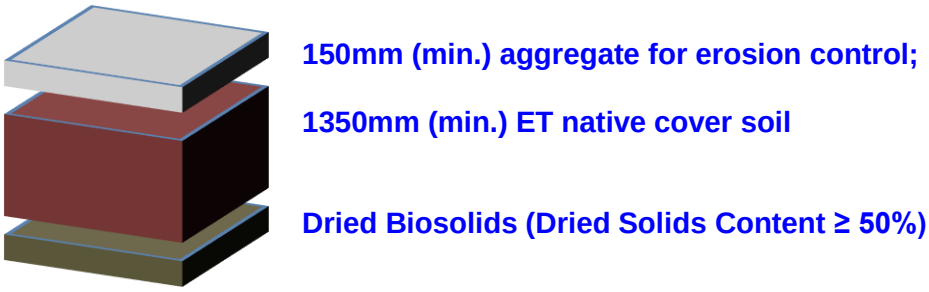

Figure 3.2: As Samra Biosolids ET Cover System

4 Personnel and Training

4.1 Manpower

The proper operation of the monofill during the active life and post-closure (aftercare) period requires a staff of trained personnel. The hiring and training of personnel shall be the responsibility of Management. The typical team required is listed below.

Table 4.1 Manpower Summary

Development Stage	Position	Number of Staff	Minimum Responsibilities
Operations	Monofill Manager	1 full time	• Personnel oversight • Public and regulatory interfaces
	Operations Supervisor	1 full time	• Operator oversight • Disposal/Closure/Gas implementation • Contractor/engineer interface
	Clerk	1 full time	• Records Management
	Safety & Compliance	1 full time	• Safety training/compliance • Reporting
	Equipment Operator	3 full time	• Biosolids disposal
	Electrician/ Instrumentation	1 full time	• Biogas/leachate technician
	Mechanic	1 full time	• Disposal vehicle maintenance
	Laborer	2 full time	• Manual laborer landfill O&M
	Security	3 part time (for day and night shifts)	• Fence/gate/facility patrol
Post-Closure	Management	1 part time	• Personnel oversight • Post closure O&M implementation
	Administrator	1 part time	• Records management
	Safety & Compliance	1 part time	• Safety compliance • Reporting
	Technicians	2 part time	• Biogas/leachate technician
	Security	3 part time (for day and night shifts)	• Fence/gate/facility patrol

4.2 Expanded Responsibilities of Management

Management typically encompasses a wide range of tasks pertaining, but not limited to, ensuring regulatory compliance, monitoring and reporting, maintenance of facilities, environmental controls, emergency response and communications with the general public. Continuity of management over the life of the site is desirable, and a site should be managed, in an engineering sense, from the time of initial site selection to the day when

the facility is closed. An expanded summary of the tasks associated with management of the monofill is presented in the Table 4.2.

Table 4.2 Summary of Tasks Typically Assigned to Manager(s)

LANDFILL MANAGEMENT TASKS
1. Waste placement, compaction, and grading – Guarantee compliance with filling patterns (in line with design parameters and cell capacities) – Operate compaction equipment and requisite machinery – Ensure compliance with necessary grading requirements through adequate placement and compaction – Perform compaction density calculations
2. Cover Materials – Apply daily soil cover – Apply intermediate and final covers – Repair and maintain cover systems
3. Screening and Removal of Prohibited and Hazardous Materials – Understand and identify prohibited/hazardous and dangerous materials – Remove and safely store/dispose of prohibited materials – Maintain records regarding management of prohibited/hazardous and dangerous materials in line with regulatory requirements
4. Maintenance of Functioning Units – Ensure provision of adequate stormwater controls – Ensure sufficient controls of blowing litter – Maintain cover soils – Control odors – Inspect and control seeps – Maintain access roads and other on-site infrastructure
5. Leachate Management – Operate and maintain liquid collection and removal system – Operate and maintain leachate treatment and disposal system
6. Gas Management – Monitor, operate and maintain extraction and collection system – Monitor, operate and maintain gas flaring system
7. Auxiliary Operations and Practices – Operate and maintain weighing station(s) and scale-house(s) – Operate and maintain road and storm-water drainage systems – Safeguard and maintain groundwater wells and gas monitoring probes – Operate and maintain structures and facilities – Maintain site aesthetics
8. Non-Functioning (Closed) Site Operation, Monitoring and Maintenance – Ensure generic maintenance and control of site – Operation of leachate management and gas collection systems
9. Compliance – Understand all applicable regulatory and permit requirements – Ensure site compliance with all approvals – Maintain records and submit relevant reports – Coordinate compliance inspections with relevant bodies and address concerns
10. Accounting and Record Keeping – Gather and organize waste receipts and tonnage records – Collect and maintain facility operational – Perform basic landfill economic assessments

11.	**Safety and Contingency Planning** – Develop and enforce appropriate safety precautions and emergency response plans – Keep records of safety parameters to ensure compliance with safety and contingency requirements – Facilitate training for employees, visitors, customers, scavengers, etc. on safety and contingency measures
12.	**Communication and Liaison** – Effectively communicate with employees – Effectively communicate with customers – Effectively communicate with visitors, neighbors and the general public – Effectively communicate with senior management, regulatory bodies, and consulting engineers

4.3 Initial Training

Initial training of employees shall be the Management team's responsibility. New employees will be hired as the need arises to fill vacant or open positions. Employees are briefed on the facility history and operations during initial orientation. The equipment operators and laborers will be instructed on the importance of the liner system components as related to environmental protection and the operational procedures that will prevent liner system failures. Operations personnel selected for potential employment will be required to take a comprehensive physical examination and drug-screening test prior to employment. Results of these tests may be used to screen out potential employees or to establish a baseline health determination for use in comparison to future physical evaluations.

4.4 Job Specific Training

Training of employees in the skills required for their duties shall be the Management team's responsibility. Where necessary for certification, training by outside professional sources or government agencies will be utilized. Employees will also require training in safety (see below), administrative procedures, security, maintenance, public relations, waste landfilling, and waste inspections.

4.5 Safety Training

The management team will be responsible for development and implementation of a comprehensive safety program. The Manager's direct involvement in the program is essential for it to be effective. Safety rules and procedures will be prepared in written form, posted on the site, and distributed to each employee.

Each employee at the facility will be trained in proper work procedures, safety, and emergency response procedures. Employees who may be handling any potential harmful materials will be educated on proper material handling, compatibility, spill prevention and clean-up along with all applicable right-to-know requirements. Emphasis will be placed on prevention of potential emergency situations; however, emergency response practices are also covered.

Employees will be trained during their initial employment period. In addition, safety meetings will be held periodically. During these meetings, basic safety practices will be reiterated and any subsequent changes to facility operations or emergency response procedures discussed.

5 Operation and Maintenance

5.1 General Information

5.1.1 Hours of Operation

Dried biosolids shall only be accepted at the monofill working face during normal operating hours and are subject to inspection prior to dumping. Lighting will be provided to the working face during non-daylight hours.

Proposed operating hours at the As Samar Biosolids Monofill are 8 hours per day, 5 days a week from Sunday through Thursday. The site will be closed on Friday and Saturday. During emergency situations the site may extend hours during the week or accept biosolids on Friday and Saturday.

5.1.2 Entrance and Infrastructure Area Facilities

The Facility Entrance and Infrastructure Area shall support the ancillary activities necessary to operate and manage the lined disposal areas and is the initial area encountered by vehicles entering the facility. The following features that are part of the entrance and infrastructure facility:

- **Fencing and gates** – Access to the facility shall be secured by a 2000-mm-high (nominal) security fence with 3-strand barbed wire extension and locking gates. Width of vehicle access gates, which will be comprised of two swing leafs, shall be a minimum 6000 mm (nominal). All gates shall be securely locked during facility off-hours.

- **Administration Building** – The former administration and chlorine handling building has been retrofitted to serve as the administration building and provides an entrance hall, office space, first aid area, a meeting/conference room, filing/storage, a mess/kitchen, separate men's and women's lavatory/shower facilities, and a workshop/storage area. The building is equipped with external/internal lighting, portable fire extinguishers, and appropriate personal protective equipment (PPE) for monofill personnel (hard hats, high-visibility safety vests, hearing protection, etc.) with sufficient reserves for use by authorized visitors.

- **Scale Facility** - A modular, steel, fully electronic (compatible load cells, computer software, hardware, communications and recording, etc.) industrial truck scale will be located at the monofill entrance road/ramp area east of the administration building. The scale facility will have a standby backup generator with an automatic transfer switch to provide nearly continuous emergency electrical power to operate the truck scale and scale house weighing equipment/software. The system will include provisions for one truck scale certified for 60 tonnes overall weighing capacity (concentrated load capacity of 30 tonnes) and equipped with solid state data center. The system will also include a surge voltage lightning protection package. A typical operating cycle for the scale when the truck tare (empty) is not known is as follows:

  1. The scale is vacant with a stop-go light signaling the truck to pull onto the platform.
  2. The system automatically detects the truck, and the gross weight is displayed.
  3. The computerized system automatically enters a blank ticket into the printer.
  4. The motion detection system senses that the scale has stopped oscillating and the scale reaches equilibrium.

5. Print “ready” light comes on.
6. Scale Operator presses the print button, and the indicated weight and the time and date are recorded.
7. Scale Operator makes any pertinent notations on the scale ticket and may communicate with the driver if necessary.
8. The truck then proceeds to the disposal area to be unloaded.
9. The scale is now empty and ready for another weighing.
10. On the way out, the hauler is re-weighed to obtain a light, or “tare” weight. The truck pulls onto the empty scale following the above-described truck entry procedures.
11. Indicator displays weight, and print “ready” light comes on.
12. Ticket is inserted while step #11 is taking place.
13. The Scale Operator then refers to his file to determine the known tare (empty) weight and enters this into the indicator.
14. The Scale Operator presses the print button; and gross weights, tare, net weight, time and date are recorded.
15. The hauler then signs his ticket (if necessary), receives one copy, and the operator files the others.

- **Maintenance and Equipment Parking Area** - Parked construction/operation vehicles will be stored within the fenced area west of the administration building. A sloped concrete pad of sufficient size to accommodate the largest piece of equipment will be located within the fenced area with curbing along the perimeter of the pad. This pad will be utilized to contain potential spills during any required engine work, lubrication, or any fluids transfer (other than vehicle fueling) related to maintenance.

- **Gas/Stormwater/Leachate Management Areas** - The Facility and Infrastructure Area includes structures for management of the landfill gas (LFG) collected from the monofill area. A 1200-mm-diameter HDPE landfill gas condensate knockout will be located at the low point of the HDPE landfill gas header as it enters the infrastructure area. Condensate collected within the knockout will be drained via a 110-mm-diameter HDPE drain pipe to a buried condensate holding tank. Condensate will be periodically pumped out of the storage tank for off-site disposal. After the condensate management knockout, the landfill gas header will be routed to a blower/flare station for destruction of landfill gas. A small monofill gas generation power facility will be constructed with a backup utility flare station. Individual 2,000 KVA generators will be acquired in increments 3 or 4 years apart and phase in and out of operation to meet the variable capacity required over the project life. If sale and conveyance of treated or untreated gas to off-site end users is pursued, gas compressors would also be acquired and phased into and out of the gas management infrastructure to meet the variable capacity required over the project life.

- **Fuel Dispensary** – An above-ground equipment fuel dispensary (storage tank, manual or electrically operated fuel transfer pump, filling hoses) will be installed within the securely fenced area for use by operations equipment and on-site vehicles. The storage tank will be located within a secondary containment berm or tank to contain potential leaks.

5.1.3 Liquids Management

- **Leachate Storage/Evaporation Lagoon** - A lined leachate evaporation lagoon with the capacity to store the design leachate production volume with sufficient freeboard to contain precipitation will be constructed. The lagoon will receive pumped leachate from each disposal cell via HDPE force main and will be located along the northern edge of the monofill where collection sumps are oriented to minimize pumping/piping requirements. The 2-meter-deep lagoon has been designed with approximately 3,613 cubic meters (3,613,000 liters) of storage capacity from its invert to its crest.

  For the As Samra site, only passive/natural evaporation from exposure of the contained water surface to solar radiation and wind is proposed. No additional enhanced evaporation by hydraulic or mechanical means such as sprinklers, misters, or aerators is proposed. The leachate lagoon will be lined with a base liner containment system anchored at the lagoon crest. The liner system will consist of the following components in ascending order over the excavation/subgrade:

  - 150 mm (minimum) of compacted select fill/liner cushion soil material
  - 1.5 mm (60mil) textured HDPE geomembrane liner

- **Stormwater Management Basin** - A lined stormwater management basin will be constructed near the northwest corner of the monofill to manage the maximum anticipated runoff from the monofill development area phases as well as runoff from limited adjacent areas. Overflow from the basin will be re-directed through a trapezoidal weir back into the existing wadi. For the As Samra site, only passive/natural evaporation from exposure of the contained water surface to solar radiation and wind is proposed. No additional enhanced evaporation by hydraulic or mechanical means such as sprinklers, misters, or aerators is proposed. For added conservatism, evaporation of stored water ***has not*** been accounted for in stormwater management basin sizing. The basin storage capacity from its invert (elevation 537.5) to its crest (elevation 541.0) has been designed as 6,465 cubic meters (6,465,000 liters).

  To facilitate storage and retention of water and to protect the adjacent perimeter berm from scour, the stormwater management basin will be lined with a base liner containment system anchored at the basin crest consisting of the following components in ascending order over the excavation/subgrade:

  - 150 mm (minimum) of compacted select fill/liner cushion soil material;
  - GSE "Bentoliner CNSL GCL" (Geosynthetic Clay Liner with a polypropylene geofilm adhered to the upper surface), or approved equivalent; and,
  - 300-mm-thick (minimum) native soil cover layer with 25 mm maximum particle size

5.1.4 Mobile Equipment

The As Samra Biosolids Monofill will maintain the vehicles and heavy equipment shown in Table 5.1:

Table 5.1 Summary of Mobile Equipment

Equipment Type	Units	Use
Low Ground Pressure (LGP) Bulldozer	1	• Initial biosolids spreading • Basin or lagoon cleanout • Other activities requiring LGP • Extended biosolids spreading
General Purpose Bulldozer	1	• Extended biosolids spreading • Daily cover soil operations • General earthmoving
Dump Truck	1	• Daily cover operations
Backhoe Loader	1	• Utility trenching • Light and piping equipment transfer • General maintenance
Front End Wheel Loader	1	• Extended biosolids spreading • Daily cover operations • General earthmoving
4-Wheel-Drive Pickups	2	• On-site Inspections • On-site sample transport • On-site personnel transport
Water Truck	1	• Dust Control

Mobile equipment will generally be maintained by the on-site mechanic. O&M will typically include (but is not limited to) changing of fluids, filters, belts, and plugs; lubrication; tire inflation and rotation; and any other maintenance required to extend the equipment life and/or to maintain the terms of the equipment manufacturers' warranties.

5.1.5 Recordkeeping for Waste Disposal Operations

The monofill will maintain all facility inspection documents in addition to daily logs concerning the waste stream on-site. At a minimum, these logs will include the data, quantity of refuse by weight or volume, and origin of refuse.

5.2 Waste Handling

5.2.1 Traffic Routing

A sign or signs will be posted at the main entrance road leading to the scale listing operating hours, emergency contacts, acceptable waste materials, prohibition of hazardous and unacceptable waste, etc. Trucks will enter via the paved access roadway and will proceed onto the scales to be un-tarped (if necessary) and weighed. Scale house personnel will weigh-in the vehicle and then direct it to re-tarp (if necessary) and proceed to the active disposal area. Beyond the scale, the traffic will be directed by signage along the perimeter access road to the active working face. Once at the active area, the spotter(s) and/or equipment operators instruct the drivers where to un-tarp and unload. After unloading, vehicles return to the scale area. Trucks need not be weighed upon exiting the facility if tare weights are known.

Disposal cells will be accessed from the perimeter access road on top of the perimeter containment berm. Temporary ramps and access roads (typically 5 meters wide) leading from the perimeter will continually change as the working face moves both horizontally and vertically as each cell grows. A working knowledge of the capability of the vehicles entering the cell in relation to the conditions (wet, freezing, dusty, etc.) affecting ground mobility is imperative.

The cell haul roads at maximum fill heights will generally not exceed a grade of 12% for sustained lengths. In dry weather, with a reasonable road surface and competent drivers, access should be relatively easy. During falling weather conditions and during times when vehicle congestion is anticipated (especially approaching maximum fill heights), access may require additional oversight and maintenance.

Experience in day-to-day management and observation of varying field conditions may allow the Operator to modify the access scheme as-needed to balance operation costs and times. The use of steeper grades may result in a shorter cycle time (reduced length of travel and the increased speed of turnaround for all types of vehicles), provided a well maintained road is provided.

5.2.2 Placement, Spreading and Compaction of Biosolids

Based on the testing program and results for biosolids from the As Samra Waste Water Treatment Plant, it is assumed that biosolids will be dried prior to deposition at the monofill such that solids content (mass of solids divided by total mass) is >= 50%.

Disposal of biosolids within the monofill will be limited to periods when precipitation is not forecasted. Stability of the landfill, prevention of odors, minimizing the potential for contaminated stormwater runoff, and prevention of re-activation of biological processes are predicated on “dry” conditions and careful attention to application of daily cover soil and the ET cap on finished surfaces. Disposal operations will also be suspended during periods of high winds in order to limit the potential for fugitive odors and blowing dust emissions from dumping and spreading of dried biosolids.

The area method of landfilling will be used at this site for biosolids filling operations. Dried biosolids will be unloaded either at the toe or at the top of the inclined working face within the active cell or cells. An approximate 1000 mm thick initial “fluff” layer of dried biosolids will be placed over the base liner system and protective cover/drainage layer by a Low Ground Pressure (LGP) bulldozer under the supervision of a spotter/inspector. LGP equipment will be used to protect the base liner from potential damage during initial biosolids placement. While foreign materials are not anticipated, the initial layer will be free of objects which could potentially penetrate the protective cover and possibly puncture the liner.

Dried biosolids in subsequent lifts will be spread and compacted by a general purpose bulldozer in approximately 600 mm thick layers in a daily “cell” immediately after unloading in the active area. Each lift will then be compacted by a minimum of three (3) passes of a bulldozer. Following compaction, additional biosolids will be placed to construct the next lift.

5.2.3 Prevention of Unacceptable Waste

The As Samra Biosolids Monofill is intended only to accept dried biosolids with solids content ≥ 50%. To prevent disposal of unacceptable waste, such as biosolids that have not yet achieved the desired solids content and/or any other waste materials other than biosolids, the spotter(s) and equipment operator(s) at the working face will be trained to detect unacceptable wastes. Any questionable material will be set aside (i.e. isolated) for further inspection. If unacceptable waste is found and the transporter is known, then the truck will be reloaded with all unacceptable waste. If the transporter has departed, the unacceptable material will be loaded into a lined roll-off container and covered until the generator is notified for return and retrieval of the material. Alternatively, the facility may take responsibility (at cost or surcharge to the transporter) for proper off-site disposal in conjunction with companies registered and permitted to handle these wastes. A written

report of all unacceptable wastes rejected by the facility will be compiled in the Operational Record.

5.2.4 Filling Patterns

The site supervisor, contractor and equipment operators will confer daily to set the fill limits for daily disposal operations. The limits of the working face will be marked by visual references such as poles or stakes, with colored flags or traffic cones. The working face will be generally be limited to areas that are accessible by the daily access roads to the tipping face, and will be in close proximity to the tipping operation.

Trenches excavated within the deposited biosolids for the purpose of horizontal gas collection trenches will be sloped “into” the landfill, away from the 3:1 exterior slopes so the trenches do not form a potential conduit/channel for precipitation or gas condensate drainage onto finished slopes.

As areas reach final biosolids disposal elevations, the ET cover will be placed together with the construction of the permanent access roads, surface water ditches and gas management system components.

5.3 Daily Activities

The following is a description of typical daily operations of the As Samra Biosolids Monofill facility.

5.3.1 General

At the end of the previous day’s operation, management and/or operations personnel shall verify the proposed daily waste vehicle traffic movements and provide additional traffic controls such as barricades or signage to direct truck drivers to and from disposal cells.

At the start of daily operations, the weigh-master shall log-on to start the weighing software. The site shall be maintained as “secured and locked” until the time the scale house equipment is ready for operation. Early-arriving trucks may be allowed to queue along the entrance road.

The working face shall be aligned and located to limit wind exposure, to limit exposure to precipitation and stormwater run-on, and to limit stormwater run-off. Biosolids exposed to rainfall must be directed into the monofill where it can be captured by the leachate collection system. At end of daily waste disposal activities, the scale shall be closed and secured and daily cover applied to biosolids placed that day.

5.3.2 Daily Cover

A minimum of 150 mm of soil or an approved equivalent cover will be placed on all exposed biosolids at the end of each day’s work so as to minimize or eliminate potential odors and vectors and to minimize potential stormwater contact. The daily cover will be either on-site or off-site soil, or an approved alternate material (geomembrane, tarps, 70/30 shredded tires/soil mix, spray-applied product such as Posi-Shell®). When soil (or soil/other material mixtures) is used, the cover will be spread over the exposed biosolids and placed to a final thickness of at least 150 mm using a bulldozer.

Daily cover soil will consist of soils previously excavated during cell construction that have been stored within the on-site stockpile area. A seven-day supply of soil will typically be transferred from the stockpile area to a secondary stockpile immediately adjacent to the

active filling area so that daily cover operations may be performed efficiently at the close of each work day, and for instances where additional odor/nuisance control is warranted.

5.3.3 Intermediate Cover

Operating areas which will not be used again for more than 30 days will be covered with an additional 150 mm of compacted earthen material herein referred to as “Intermediate Cover.” This intermediate cover will be placed over alternate daily cover or in addition to (150mm of soil) daily cover. The top of this cover may later be scraped back and used for daily cover when the area is once again operational. Additional cover material will be placed on all cracked, eroded and uneven areas as needed. Intermediate cover will be capable of supporting vegetation, if required. At no time will interior slopes (temporary interim slopes) exceed 6H:1V. Intermediate cover soil will also consist of soils previously excavated during cell construction that have been stored within the on-site stockpile area.

5.3.4 Evapotranspiration Cover

The evapotranspiration (ET) final cover is designed to:

- Reduce infiltration;
- Encourage run-off; and,
- Reduce landfill gas migration and enhance extraction.

After final biosolids placement, a monolithic ET cover will be installed. The surface of the ET cover will then be covered with an aggregate layer for erosion control. The ET cover was chosen due to its proven suitability in arid and semi-arid areas, its limited long-term maintenance requirements, as well as its economic feasibility. The ET cover design for the As Samra monofill will consist of a minimum of 1350 mm (1.35 m) of ET native soil cover overlain by 150 mm (minimum) of aggregate for erosion control.

5.3.5 Containment Berms

When necessary due to falling weather conditions, earthen containment berms shall be constructed to prevent generation of contaminated run-off. The containment berms would typically be fashioned of soil with 300 mm high and have a 300-mm-top width with maximum 2:1 sloped sides. Active areas and containment berms shall be sloped into the active monofill leachate collection system to allow for the leachate generated to be captured by the leachate collection system.

5.3.6 Site Appearance

Daily cleanup will be emphasized at the entire facility in order to provide a continually safe and efficient working environment, while minimizing visual intrusion to the surrounding area. Daily cover will be placed over exposed biosolids at the end of each workday. A flush truck will be used, if necessary, on access road surfaces to clean up mud and excess dust accumulation. A tire wash may also be installed to clean the tires and undercarriages of vehicles prior to leaving the site. Periodically, heavy equipment will be cleaned and washed with low volume, high-pressure washers at the working face of the landfill.

5.3.7 Fire Protection

No hot or smoldering waste shall be accepted at the monofill, nor shall any burning be initiated at the site. All major mobile equipment and transportation vehicles must contain a fire extinguisher capable of fighting small fires. Personnel at the facility shall be

specifically trained in extinguishing landfill fires. Should hot or smoldering material be detected, the material shall be isolated and the manager's office contacted using the facility's internal communications network. The smoldering material will be isolated and excavated, spread in a thin layer off of the working face atop daily cover soil, and saturated with water or soil to extinguish the fire. A sufficient amount of time must elapse to ensure complete extinguishment. The local fire department will be notified if on-site personnel are unable to control a fire.

5.4 Nuisance Control

5.4.1 Dust

A dust control program will be implemented to control the level of dust at the facility and will contain the following components:

- A gravel perimeter access road in and around the monofill area will be properly maintained to reduce the generation of airborne particles.

- Dust will be primarily controlled through the application of water to access roads and other surfaces from which it is being generated. A truck equipped with a portable water storage tank (water truck) and a spreader bar will be used periodically to dampen these surfaces as conditions warrant. Commercially available chemical dust suppressants may also be utilized to minimize dust. Dust palliatives may be employed as needed.

5.4.2 Odor

The operators at the site will control odors utilizing the following procedures:

- The monofill will be operated in a manner, which controls the odors associated with the disposal of dried biosolids. Biosolids will be covered with daily cover material. In addition, during certain weather conditions, it may be necessary to apply daily cover during the day to reduce the amount of uncovered biosolids.

- A gas collection system will be maintained at the facility to control gas emissions.

- Chemical odor control, masking or neutralizing agents may be used. These may be applied to the working faces, perimeter roads or other areas deemed necessary.

5.4.3 Vectors

The facility will be operated in a manner that minimizes the propagation and harborage of flies, rodents and birds.

- The application of daily cover will help control all types of vectors by protecting against the migration of rodents, birds and the propagation of insects. In the event that a rodent or other vector problem is evident at the facility, a licensed exterminator will be employed to control vector breeding.

5.5 Adverse Weather Conditions

5.5.1 Wet Weather

Disposal operations will cease during wet weather as the dry solids content of biosolids (>= 50%) is paramount to the stability of the landfill. When wet weather is forecast, special focus shall be given to ensuring that all exposed biosolids are covered with at least 150 mm of daily cover soil or approved alternate material.

5.5.2 Windy Weather

In the event of extreme windy conditions, disposal operations will cease in order to eliminate the potential for biosolids particles to become airborne. When windy weather is forecast, special attention shall be paid to ensuring that all exposed biosolids are covered with at least 150mm of daily cover soil or approved alternate material.

5.5.3 Cold Weather

While below freezing weather is not typical in Jordan, historic records indicate a lowest recorded temperature of -5° Celsius (around 24° Fahrenheit). Mechanical, pneumatic and hydraulic systems are normally protected against cold weather by burying or application of insulating materials. Exposed piping and equipment in the blower/flare and leachate collection facilities may be insulated or heat tracing may be applied.

During extreme cold weather, ice-blocking due to collected leachate or condensate in improperly sloped pipes may be a problem even with a buried and insulated system. The best procedure may be to shut down or reduce flow until the blockage thaws and clears. If the system freezes, excavation, replacement or thawing of the pipe(s) may be required. If the pipe is buried in the monofill, placing insulating material or additional soil cover over the top will help by allowing the monofill heat to thaw the pipe. If the problem is localized, the situation may be correctable by increasing insulation, correcting piping slope or drainage, or installing a larger section of pipe. A temporary repair may be necessary until a permanent solution can be implemented.

5.6 Leachate

5.6.1 Collection System and Maintenance

Exposed leachate management system components will be inspected on a routine basis during acquisition of leachate flow data. The leachate technician will visually inspect all leachate piping, valves, meters, hoses, and connections for signs of leakage, damage or excessive wear.

5.6.2 Storage and Treatment System and Maintenance

All generated leachate will be collected and pumped from the individual disposal area sumps to the leachate storage/evaporation lagoon area. While mechanical aeration may be proposed in the future if necessary, the current primary means planned for leachate management is evaporation. The leachate evaporation lagoon will also be inspected, focusing on holes and tears in the liner system.

5.7 Landfill Gas

5.7.1 System Description

The LFG management system will consist of permanent vertical extraction wells, transmission piping, condensate collection and handling facilities, a blower to draw the LFG from the well field, and a backup flare to reduce atmospheric emissions.

Horizontal gas collection trenches will be installed within the monofill to allow for the collection and transmission of LFG from the lower elevations (depths) prior to installation of the ET cover system and/or when vertical drilling is impractical due to shallow biosolids depths. Collection trenches (perforated piping within a granular trench) will be sloped away from the extraction trench head location into the waste at slopes no shallower than 1% (0.01 meter/meter). To help minimize air intrusion, it is recommended that biosolids reach a minimum height of 5 meters above the trench crest prior to activating the trench.

Vertical gas collection wells are typically drilled through the mass of deposited material as final disposal elevations have been reached and intermediate cover has been installed. While they may also be installed at lower waste elevations as “temporary” wells, a minimum clearance of 4.5 meters shall be provided between the base of the well and the protective cover layer of the base liner system for both “temporary” and “permanent” wells.

The LFG laterals and header piping will be installed within a compacted backfill layer with a minimum of 150 mm of compacted backfill above and below each pipe. This will facilitate the collection of LFG and provide structural support to the pipe. A minimum 600-mm-thick (0.6m) layer of general backfill with an embedded utility identification tape will be installed above the compacted backfill, followed by the final ET cover soil. Changes in horizontal alignment and vertical PE LFG pipes shall be accomplished by taking advantage of the flexural properties of the PE pipes whenever possible. The minimum bend radius for these shall be 27 times that of the pipe’s outer diameter, or 100 times that of the pipe’s outer diameter when fittings fall on the bend.

Landfill gas condensate will be removed from the LFG header at an in-line condensate knock-out adjacent to the gas management facility. Condensate collected at the knockout will drain to an underground 37,850 liter capacity condensate holding tank via 110-mm SDR 17 PE piping. Condensate levels will be monitored periodically, with condensate pump out and transfer to either an off-site disposal facility or to the on-site leachate evaporation lagoon.

5.7.2 Pre-balancing Activities

Pre-balancing activities include the measuring of current flows, temperature and vacuums at the blower/flare station and at individual landfill gas (LFG) wellheads. Measurements are typically documented on the “Weekly LFG Flare Sampling/Inspection” and “Monthly LFG Well Sampling/Balancing” forms (See Appendix A).

5.7.3 System Balancing

Balancing a LFG extraction well system is best accomplished by monitoring the well field regularly. Each well should be monitored at least monthly for LFG composition, vacuum, flow, and temperature. The monitoring should be more frequent if the LFG is used as fuel in an energy recovery project. LFG composition measurements may include percentages

of methane, carbon dioxide, oxygen, nitrogen, and other constituent gases. If excessive vacuum is applied to a LFG well, ambient air intrusion through the cap or well seals will occur. This phenomenon is called “over-pull”. Over-pull kills anaerobic bacteria and may increase the chance for an underground fire.

The best way to monitor for ambient air intrusion at extraction wells is to check the concentration of nitrogen. Any amount of nitrogen in a MSW well is a sign of ambient air intrusion. Unfortunately, monitoring for nitrogen requires analysis by a gas chromatograph, which is time consuming and expensive. Additionally, dried biosolids contain nitrogen.

The presence of oxygen is also an indicator of ambient air intrusion. However, oxygen is stripped away as it travels through the refuse by bacteria (aerobic process). Therefore, the concentration of oxygen measured at the wellhead is typically reduced, and is not an exact measure of ambient air intrusion.

Trained LFG Technicians will use their experience to monitor and apply system adjustments where necessary to balance the collection system. The technician would typically use the following readings to gauge system performance:

- **Gas Flow Rate -** LFG flow rate is often measured using a fixed device such as a pitot tube, orifice plate, or by some portable measurement device such as an anemometer. The required flow rate at each well and for the system as a whole is generally determined empirically based on LFG composition readings.

- **System Vacuum** - Wellhead vacuum can provide a very rough estimate of radius of influence and flow rate if a pilot study or historical data has provided a correlation between wellhead vacuum and flow/radius of influence.

- **Gas Composition** - Methane, nitrogen, and oxygen are the key parameters measured. Carbon dioxide is often measured in order to indirectly determine nitrogen content, since nitrogen is difficult to measure. Carbon monoxide can be monitored as an indicator of a landfill fire (since it is generated if the LFG temperature begins to rise).

The monitored data for each well is summarized on a spreadsheet to allow for review of trends in LFG collection, so as to anticipate necessary future adjustment to maximize system collection efficiency.

5.7.4 Routine Operation and Maintenance

Gas wells will be inspected and maintained during monthly tuning events by the gas technician. Well casing, wellhead assembly, valves, flexible hose will be inspected for signs of tampering or excessive deflection. Gas movers (blowers), power generation equipment, and flare(s) will be inspected on a quarterly basis by qualified personnel in accordance with the manufacturers’ recommendations in order to extend equipment life and to maintain the terms of warranties.

5.7.5 System Operational Flexibility

A site-specific monitoring program should be established that is flexible and performance based. LFG needs to be monitored on a regular basis to enable adjustments to be made to the wells to maximize extraction, prevent migration, and minimize drawing oxygen into

the monofill. The procedures need to be regularly evaluated as changing climatic and operational conditions can have an effect on the results obtained.

The blower/flare facility shall be equipped with digital chart recorder by Yokogawa Electric Corporation, or an equivalent that displays digital documentation of burner temperature and blower flow data retrievable from remote location to verify blower/flare operations. Alarm notification shall be programmable for notification of multiple LFG technicians to minimize downtime and potential explosive gas buildup.

5.8 Environmental Monitoring

5.8.1 General

Routine environmental monitoring shall be performed at the As Samra facility including daily, monthly and quarterly monitoring of various environmental media at the site. This will consist of surface water, leachate, and gas (methane) monitoring. The monitoring would typically be performed by site personnel or third-party consultants who are trained in the technical requirements of the particular environmental monitoring event. Site inspections and monitoring events would typically be documented on standard report forms with areas to insert general site data such as the facility name/location, date, time, weather, person(s) conducting the inspection or monitoring, and any unusual site conditions. These monitoring reports include field sampling data sheets, laboratory analytical data reports, statistical calculations, data validation reports, leak detection and collection system pumping records and conductivity measurements, landfill gas monitoring reports and extraction well 'as-built' records. All reports shall be maintained at the As Samra facility and would be made available for review in hardcopy upon request from Regulatory Authorities.

5.8.2 Leachate Collection System

Daily leachate flow monitoring (total monofill flow and flow from individual cells) is typically recorded on a daily basis at each cell by flow totalizing equipment during the acquisition of the leachate flow data. The condition of the exposed mechanical piping will be checked. The technician will visually inspect all of the leachate piping, valves, meters, hoses, and flange connections for signs of leakage, damage or excessive wear. The technician will notify site management of any required repairs. Leachate pumps will also be inspected and maintained in accordance with the manufacturers' recommendations in order to extend equipment life and to maintain applicable warranties.

5.8.3 Leachate Head Levels

The leachate collection system has been designed to ensure that no more than 300 mm of leachate will be present above the liner at any time. Leachate is removed from the cells by submersible pumps and transported via a force main to leachate storage facilities. Head within each cell will be monitored using transducers attached to the side slope riser pumps. The head on the RCRA liner will be restricted to 300 mm above the liner at the sump locations.

Ponded leachate within the landfill will also be monitored as ponding indicates lack of percolation of liquid to the base line and leachate collection system and can lead to breakouts of leachate onto finished slopes, cross-contamination of leachate into stormwater management systems, inefficient landfill gas collection, and potential stability concerns.

Table 5.2 summarizes actions to be taken for various leachate flow conditions:

Table 5.2 Leachate Head Action Table

OBSERVED CONDITIONS	ACTIONS/PROCEDURES
Ponded Leachate	1. Pump standing water to tanker trucks or to the leachate force main for transmission to the leachate evaporation lagoon. 2. The ponded area will be excavated to assist in allowing the uncollected liquid to flow vertically into the underlying deposited biosolids, and to allow drying of scarified material. 3. Take necessary measures to prevent leachate from flowing laterally beyond the lined area of the cell.
Excessive Head	4. Pull and inspect the leachate pumps for those areas of the site to verify that they are functioning properly. 5. Repair/replace pumps accordingly. 6. Monitor decreasing head over time.

Leachate head levels and flow are typically measured continuously at the sump locations.

5.8.4 Landfill Gas Subsurface Monitoring

Air quality monitoring will be performed in accordance with 40 CFR Part 258.23, “Explosive Gases Control”. It is crucial that a routine methane monitoring program be implemented in order to ensure the set standards are met as outlined. In addition, landfill gas control is a requirement of Subpart C and EPA’s New Source Performance Standards and Emission Guidelines for municipal solid waste landfills - NSPS/EG 60.759.

During active operations and during the post-closure period, gas migration (barhole probes and structures/buildings) monitoring is required on a quarterly basis. Barhole probes will be monitored for: (1) gas pressure (2) combustible gas concentrations and (3) liquid levels. When the sustained gas concentration of a probe measurement indicates a high concentration of combustible gas, local area barhole probing will be extended at approximate 15-meter maximum intervals (radially in all directions) in an effort to determine the extent of migration (i.e. until readings of zero are obtained). When assessing the readings, the monitoring technician should be aware that the correlation between observed gas concentrations in the probe and that for the surrounding barhole probe readings may be dependent upon factors such as ambient conditions, probe depth and site geology.

Field sampling results to be reported should be evaluated using the Explosive Gas Threshold Limit (EGTL) which is 100 percent of the lower explosive limit (LEL) at the facility boundary and is 25 percent of the LEL for onsite building structures. For methane, the LEL is five percent (5%). Therefore, the EGTL is 5% at the facility boundary and 1.25% for onsite building structures.

Upon findings of high concentration of combustible gas levels at the property boundary or within a reasonable distance from an occupied dwelling, the following contingency procedures should be implemented.

a) Gas monitoring personnel will verify any EGTL exceedances by immediate retesting, and conduct barhole probing in the area surrounding the original barhole station or probe in an effort to determine the extent of shallow surface migration. They will validate reading by recalibrating the gas instrument to make sure it is working.

b) Upon verification of a reading at or above the limit, monitoring personnel will immediately notify the Landfill Management Team.

c) Upon verification of a reading at or above the EGTL the Landfill will immediately notify the appropriate public safety authorities. These shall include, but may not be limited to, fire department and police department.

d) Immediate adjustments to the active gas system should be made in the vicinity of the noted exceedances, unless such adjustments will directly interfere with effective leachate management or have the potential to cause a landfill fire.

The Subsurface Migration Monitoring Plan will be assessed on a regular basis during the post-closure period. Should a trend of exceedances be indicated at a particular barhole probe location for three consecutive monitoring events, a permanent probe will be installed at that location.

5.8.5 Landfill Gas Collection system Monitoring

The gas collection system is monitored monthly for methane, oxygen, nitrogen, temperature and pressure during well balancing by the landfill gas technician(s).

5.8.6 Other Landfill Gas and Emissions Monitoring

Landfill gas and condensate characterization analytical results are attained on an annual basis. Other annual testing/reporting for air emissions compliance may be required on an annual basis. Landfill gas flare stack testing is typically accomplished at 5-year intervals.

5.8.7 Surface Water

The drainage and erosion control system (surface water) will be inspected weekly as part of the routine facility inspection and after significant rainfall events. Specific areas of interest will be erosion on the monofill surface, displacement or deterioration of erosion control materials, clogged pipes and structures, drainage channel blockage and/or settlement causing stagnant water, and unusual debris. Deficiencies will be noted and corrected as soon as practical. Maintenance may consist of replacing eroded soil and gravel, removing and replacing displaced or deteriorated erosion control material, cleaning pipes and structures, or removing sediment from basins.

During monofill operation, and for 30 years after closure, specific chemical and physical parameters are monitored as indicators of the potential contamination of surface water. Note that it is possible to modify the list of parameters after landfill closure (A parameter can be removed from the list if surface water has been consistently analyzed and the parameter has never been detected during the active life of the landfill). Examples of general parameters of concern include:

- Specific conductivity (field parameter)
- pH (field parameter)
- Dissolved oxygen (field parameter)
- Turbidity (field parameter)
- Temperature (field parameter)
- Colors and sheens (by observation)
- Unionized ammonia (lab parameter)
- Total hardness (as mg/l $CaCO_3$) (lab parameter)

- Biochemical Oxygen Demand (BOD_5) (lab parameter)
- Lead, chromium, barium, cadmium, mercury, selenium, silver, iron (lab parameter)
- Arsenic and cyanide (lab parameter)
- Nitrate (lab parameter)
- Total Dissolved Solids (TDS) (lab parameter)
- Total Organic Carbon (TOC) (lab parameter)
- Total and dissolved magnesium
- Total nitrogen
- Chemical Oxygen Demand (COD)
- Total Suspended Solids (TSS)
- Oil and Grease

During active monofill operations and during the post-closure period, surface water monitoring is typically required once every 6 months at the discharge after a storm event.

5.8.8 COLLECTION LYSIMETER

As Samra Landfill personnel may employ lysimeter(s) to evaluate the performance of the evapotranspiration (ET) cap system. While pre-engineered and perhaps elaborate and automated systems may be available, a simple “pan “ lysimeter could be used for the ET cap system evaluation. The lysimeter may be made from a vertically oriented pipe segment or nested open-bottom buckets of sufficient diameter to allow for installation of compacted ET cover soils and of sufficient lengths to extend through the entire ET cover thickness. The base of the lysimeter is then fitted with a screen over a collection “pan” at its base. A small pipe then drains the collection pan by gravity to a deeper closed-bottom receiving vessel with a removable cover capable of holding the largest rainfall expected at the site. Sufficient space must be available in the bottom of the receiving vessel to allow for collection of the percolated water and measurement of flow.

Average annual rainfall is very low for As Samra facility area, and when rainfall occurs it is typically brief and intense. Observation of the lysimeter shall include the:

- Document total rainfall for rainfall event
- If possible, estimate storm duration
- Measure the water percolated “P” in ml/s at the inlet pipe to the receiving vessel
- If the lysimeter is covered with snow, or if frozen, it should be left to thaw naturally. Any percolation should be measured in the usual way but irrigation water should not be applied
- During a large or prolonged rain event, periodically empty the receiving vessel when it reaches capacity and document the total volume during the storm event.

5.8.9 Annual Reporting

The As Samra Monofill Operator shall prepare copies to retain on-site and to submit to the Ministry of the Environment of an “Annual Operation Report”. Submission of an annual report for the previous year’s operations is typically required by mid-year of the current operating year.

The report shall include:

1. A topographic survey map of the same scale, contour interval and grid system as the original development site plans showing the following:

    - The contours at the beginning and the end of the year.
    - The completed areas of the site as well as areas partially filled but not active during the previous year.

2. A description of capacity used in the previous year and remaining permitted capacity.

3. A description of the acreage used for disposal and a narrative of the operator's progress in implementing its closure plan.

4. The Operator's current certificate of insurance as evidencing continuous coverage for public liability insurance.

5. Changes in the previous year concerning the information relating to identification of interests and compliance information. The report shall state if no changes have occurred.

6. A change in the ownership of the land upon which the facility is located or a change in a lease or Operator's agreement for the use of the land that may affect or alter the Operator's rights upon the land.

7. A written update of the financial liability for the facility; if additional funding is determined to be necessary, it shall be submitted to the Ministry within 90 days after the annual report is due.

8. Certification that the Operator has received the analysis or certification required for each type of industrial waste received at the facility, and that the industrial waste that is received at the facility meets the conditions in the facility's waste acceptance permit.

The report shall be used by the site and/or Ministry personnel to estimate available disposal capacity for regional planning, as well as to determine the requirements for potential environmental oversight.

6 Inspection Plan

During the active life of the monofill, facility inspections will be conducted in a manner which will ensure equipment, structures, and other related facilities are in good condition, will minimize maintenance, and help to prevent emergencies. All routine inspections will follow a predetermined schedule. The frequency of inspections for equipment will be based on the rate of potential deterioration or malfunction. Equipment inspection and service reports will be kept for each piece of equipment. All servicing, unusual incidents, and faulty operation conditions will be noted as necessary.

All mechanical equipment shall be examined to locate any potential sources of breakdown. Pumps will be checked for proper operating characteristics, and seals will be checked and replaced when necessary. Storage tanks will be painted or otherwise protected against corrosion, and pipes, fittings and valves will be adjusted, repaired, or replaced as required. Periodic inspection reports shall be reviewed to detect system components, which may require maintenance. Maintenance of improperly functioning equipment will be performed immediately, if necessary, or prior to the next scheduled inspection. Various areas on-site will have spill control equipment available in preparation of a leak or spill.

Inspections at the facility will be performed on a routine daily, weekly, and monthly basis and will be recorded on standardized forms developed by the Management Team. These inspections will include the following items:

Daily Inspections

1) Weather conditions
2) Working face(s), including compaction and cover requirements
3) General site appearance and litter control
4) Safety status
5) Leachate collection and recirculation systems
6) Incoming biosolids inspection programs
7) Vector control measures
8) Gas and condensate management system

Weekly Inspections

1) Working faces(s), including compaction and cover requirements
2) General site appearance and litter control
3) Equipment maintenance
4) Safety meetings and inspections
5) Site perimeter fencing
6) Erosion and sedimentation controls
8) Vector control program

Monthly Inspections

1) Inspection of site perimeter fencing
2) Inspection of gas monitoring systems
3) Inspection of permanent bench marks
4) Inspection of cover and erosion/sedimentation controls
5) Inspection of leachate collection systems
6) Review of emergency procedures and equipment with appropriate employees
7) Review of inspection program for incoming waste
8) Working face(s), including compaction and cover requirements

7 Site Closure and Long-term Care

7.1 General

In addition to the specific monitoring required with Section 5.8 of this manual, additional general inspections and maintenance are required during the post-closure (long-term) care period after waste acceptance has ceased and all areas of the monofill have been closed with the ET cover system.

7.2 Final Grades and Cover

For the As Samra Biosolids Monofill, an evapotranspiration (ET) cover system is proposed as a more economical alternative to commonly used clay and/or geosynthetic liners. After final biosolids placement within an area is complete, a monolithic ET cover will be installed. The surface of the ET cover will then be covered with an aggregate layer for erosion control. The ET cover was chosen due to its proven suitability in arid and semi-arid areas, its limited long-term maintenance requirements, as well as its economic feasibility. The ET cover design will consist of a minimum of 1350 mm (1.35 m) of ET native soil cover overlain by 150 mm (minimum) of aggregate for erosion control.

7.3 Post-Closure Inspection and Maintenance

At a minimum, the activities and schedule described in the following narrative are to be employed for inspection and maintenance during the required post-closure (long-term care) period. Site management staff are to be notified immediately of any required repairs.

7.3.1 Site Security and Access Control

Routine inspections will be provided throughout the post-closure period to ensure that the perimeter security features of the facility are maintained. The following provides the minimum inspection frequency:

- Fencing to be inspected on a monthly basis
- Signs to be inspected on a quarterly basis
- Gates and locks to be inspected on a monthly basis
- Access Roads to be inspected on a monthly basis

7.3.2 Inspection of Evapotranspiration Cap Integrity

Routine inspections will be provided throughout the post-closure period to ensure that the evapotranspiration (ET) final cover system is intact. The following provides the minimum inspection frequency:

- 150-mm-thick soil or aggregate final cover and /or vegetation to be inspected on a monthly basis and after major storm events (>25mm of precipitation) for signs of stress and/or displacement
- Full depth of cover soils (150 mm cover and underlying 1350 mm ET soil) to be

inspected for potential rodent/vector damage on a monthly basis

7.3.3 Inspection of Stormwater Management Controls

Routine inspections will be provided throughout the post-closure period to ensure that the positive flow is provided within conveyance systems and to assess any damage from erosion and/or overtopping. The following provides the minimum inspection frequency:

- Internal and external basin embankment slopes will be inspected for signs of cracking or movement on a monthly basis and after major storm events (>25 mm of precipitation)

- Basin discharge structures will be inspected for damage or clogging on a monthly basis and after major storm events (>25 mm of precipitation)

- Sediment levels within basins will be compared to prescribed basin cleanout elevations on a monthly basis and after major storm events (>25 mm of precipitation)

- Drainage channels, culverts and inlets will be inspected for signs of settlement or clogging on a monthly basis and after major storm events (>25 mm of precipitation)

7.3.4 Inspection of Monitoring and Collection Systems

Routine inspections will be provided throughout the post-closure period to ensure that the proper operation of monitoring and collection systems is maintained. The following provides the minimum inspection frequency:

- Landfill gas wells will be inspected by the gas technician during monthly wellhead monitoring events. The well casing, wellhead assembly, valves, flexible hose, and connections will be inspected for signs of damage or excessive pipe deflection

- Internal components of the leachate sump houses will be inspected on a weekly basis during acquisition of leachate flow data. The leachate technician will visually inspect all leachate piping, valves, meters, hoses, and connections for signs of leakage, damage or excessive wear

- Gas mover (blowers) and enclosed flares will be inspected on a quarterly basis

7.3.5 Long-Term Care Inspection Summary

All records of inspection and maintenance will be retained by the Operator throughout the post-closure period. Table 7.1 presents a summary of the minimum inspection/maintenance schedule during the post-closure period detailed above is as follows:

Table 7.1 Landfill Post-Closure Minimum Inspections and Maintenance Schedule

Inspection/Maintenance Activity	Frequency
Perimeter Security	
• **Fences**	• Monthly
• **Signs**	• Quarterly
• **Gates/Locks**	• Monthly
• **Access Roads**	• Monthly
Cap Integrity	
• **Vegetation**	• Monthly and >= 25 mm of precipitation
• **Erosion**	• Monthly and >= 25 mm of precipitation
• **Rodent/Vector Damage**	• Monthly
E&S and Stormwater Measures	
• **Basin Embankment Slopes**	• Monthly and >= 25 mm of precipitation
• **Basin Discharge Structures**	• Monthly and >= 25 mm of precipitation
• **Basin Sediment Levels**	• Monthly and >=25 mm of precipitation
• **Channels, Culverts and Inlets**	• Monthly and >= 25 mm of precipitation
Monitoring and Collection Systems	
• **Landfill Gas Wells**	• Monthly
• **Leachate Sump Houses**	• Weekly
Leachate Storage Facilities	• Quarterly
Gas Blowers and Flares	• Quarterly

8 Emergency Response Plan

This plan is a guide and a source of information to be used in emergency situations to minimize hazards to personnel and the environment. Revisions or updates to the Plan must be made when any of the following occur:

- A pertinent facility permit is revised
- The Plan fails in an emergency
- Facility changes take place which warrant changes to the Plan
- Emergency Coordinators change
- Emergency equipment changes
- Regulated equipment is added or removed
- As otherwise required by Management

Amendments must be fully implemented within six months after the change occurs.

8.1 Discovery, Alarm and Emergency Contacts

In the event of an actual or perceived emergency, the employee first discovering or suspecting the emergency shall immediately sound the alarm (air horn if outdoors, nearest alarm if indoors) and notify the management team, who will notify emergency services as necessary. At a minimum, the following information shall be reported:

- Name, address, and phone number of the person reporting the incident;
- Name, address, and primary contact number of the facility;
- Date, time, and location of emergency;
- Description of the nature of emergency;
- Type and quantity of solid waste involved (if applicable);
- Existence of dangers to public health, safety, public welfare, and the environment;
- Nature of any injuries; and,
- Parts of the Emergency Response Plan being implemented to alleviate the emergency.

In the event of an emergency situation, the landfill must take all reasonable measures to prevent the occurrence, recurrence, or spread of the fire, explosion, or spilled infectious or other potentially harmful material to other portions of the facility. These measures include, when applicable and necessary, ceasing operations and collecting and containing released materials.

Possible sources of ignition should be removed from the incident area. Vehicles should be removed from the building and handling operations ceased until the fire or incident can be safely contained or controlled. Personnel should evacuate the incident area immediately and organize for additional measures.

A general listing of contacts is provided below and (suitably detailed) shall be posted in conspicuous and appropriate locations throughout the facility:

Table 8.1 Emergency Contacts

Contact	Title/Agency	Telephone Contact
Primary Emergency Contact	Monofill Manager	TBD
Alternate Emergency Contact	Compliance Manager	TBD
Alternate Emergency Contact	Scale Operator	TBD
Local Fire and Rescue	TBD	TBD
Local Police Department	TBD	TBD
Emergency Equipment Vender	TBD	TBD
Hazardous Waste Removal	TBD	TBD

8.2 Fire Control

8.2.1 Preparation

Preparation for responding to a fire entails having the right equipment in good working order for the type of fire that could be encountered and employees trained in the use of the equipment. Employees shall not attempt to fight a fire that is larger than the size of fire they are trained to handle.

8.2.2 Response

The extent of response depends upon the size, type, and location of the fire. Small fires may be extinguished with a hand-held fire extinguisher or appropriate extinguishing media identified below.

Employees will respond to fires they have been trained to handle, and evacuate to pre-determined locations for larger fires. Employees should not fight fires beyond the incipient stage. They should evacuate the area, sound the warning alarm, and notify the supervisor, who will summon the fire department / outside emergency services. For fires inside buildings, audible alarms should be actuated and electrical power supply should be disabled if possible.

Typical Extinguishment Methods:

- Ordinary combustibles on fire can be extinguished with water and multi-purpose dry chemicals.
- Flammable liquids can be extinguished with Type B fire extinguishers, foam, or multi-purpose dry chemical. Water should not be used on flammable liquid fires, except by fire fighters trained to use water spray or fog on such fires, because of the potential to spread the fire.
- Electric fires can be extinguished with type C or multi-purpose dry chemical. Water is prohibited on fires involving live electric circuits.

- Small fires in the vicinity of the working face shall be controlled by pushing soil onto the burning material to cut off the oxygen supply. Stockpiled soil should be available around the current working face and may be used for this type of fire protection.

- Larger monofill fires require assistance by the local emergency services.

8.3 Spills

8.3.1 Preparation

Periodic facility inspections provide a systematic management program to check for possible malfunctioning equipment and equipment deterioration that could lead to spills. Proper training in identification of unacceptable waste will limit potential spills of these materials within the facility boundaries.

8.3.2 Response

Monofill employees shall report the spill or release of harmful material into the soil, air, or water to the landfill management (supervisors). Monofill employees shall make a safe and reasonable effort to contain spilled harmful materials. Available equipment may be used to construct containment berms and channels until a cleanup effort can be assembled. However, employees untrained in spill clean-up procedures shall not attempt the clean-up of hazardous materials. If untrained employees notice signs of exposure during containment of spilled hazardous materials, such as eye or respiratory irritation, headache, nausea, dizziness, etc., they shall leave the area immediately and report the incident to the supervisor.

8.4 Personal Injury

Monofill employees, contractors and visitors shall report all injuries to Management. First aid treatment can be administered by the on-site CPR and first-aid responder. For serious injuries, the monofill operator or responsible individual shall determine whether emergency service is necessary and contact the appropriate medical facility.

8.5 Evacuation Plan

In an emergency situation, the management team is responsible for determining when evacuation of the facility is required. Imminent or actual dangers that may require evacuation include, but are not limited to:

- A generalized fire or threat of fire that cannot be avoided
- An explosion or threat of explosion that cannot be avoided
- A major spill or leak that cannot be contained and constitutes a threat to human health

When evacuation is necessary, landfill personnel and any visitors on the site will meet at the appointed muster location for headcount and then may be directed to the appropriate off-site evacuation route.

8.6 Emergency Equipment

All equipment shall be restored to working order (replenished, etc.) as soon as possible after the fire emergency has ended. Operations in the affected area shall not restart until emergency equipment has been restored/replenished.

- ***Fire extinguishers*** shall be multi-purpose dry chemical for type ABC fires. They will be placed on all mobile equipment, in the scale area, in maintenance facility areas, the administration office and workshop and at all operating and electrical equipment areas.

- ***Personal protective equipment*** (PPE) for operations personnel shall be issued upon hire and will be maintained in on-site locker facilities. Additional equipment will be maintained by the management team for the use of visitors or for replacement/replenishment purposes. Minimum PPE maintained at the facility will consist of hard hats, safety goggles, high-visibility vests, work gloves, and hearing protection.

- ***Stockpiled cover material*** shall be used for spill and/or fire control in the vicinity of the working face.

- The weigh station, administration office, and major pieces of construction equipment shall be equipped with 2-way radios or management-issued cellular phones to facilitate emergency and routine ***internal/external communications***.

- Buildings will be equipped with smoke and fire ***alarm systems***. An emergency siren will also be available at the scale house for use in an emergency.

- A portable or submersible ***utility pump*** shall be used to extract water from the stormwater management pond for use in the event of a fire. The pump may also be used for the dewatering of low-lying areas due to localized flooding.

- A ***water truck*** will be kept and maintained in the equipment maintenance area and will be used exclusively for this facility. The water truck will generally be used to spray the access roads and fill areas during abnormally dry conditions but can be used as an auxiliary pumper when required for fires.

APPENDIX A
PERIODIC INSPECTION AND MONITORING FORMS

- DAILY LANDFILL OPERATION REPORT
- COMPLAINT NOTICE
- MONTHLY SITE INSPECTION FORM
- EROSION & SEDIMENT CONTROL INSPECTION SHEET
- OPERATIONAL RECORDS INSPECTION FORM
- WEEKLY LFG FLARE SAMPLING/INSPECTION
- MONTHLY LFG WELL SAMPLING/BALANCING
- QUARTERLY LFG SURFACE SCAN
- LFG PROBE MONITORING FORM
- CHAIN OF CUSTODY RECORD